CEMVRPM 6 Feb. 2003

MEMORANDUM FOR RECORD

SUBJECT: UMR-IWW Navigation Study, Scenario Probabilities

1. In accordance with comments received on the Draft Interim Report, the study team has explored opportunities for identifying probabilities as part of a sensitivity analysis during the formulation process. This memorandum contains the background, evaluation of options, and initial recommendation on this issue.

2. **Background.** The scenario analysis was pursued based on a recommendation from the Federal Principals Task Force, in an attempt to address the difficulties and uncertainties associated with making 50-year traffic forecasts. The product of this effort was the development of five scenarios that ultimately described alternative levels of unconstrained waterway traffic forecasts for the Upper Mississippi River-Illinois Waterway (UMR-IWW) system. Construction of the scenarios flowed from the effects of thirteen influential variables, which were classified into four "scenario drivers". While constructed to represent a range of outcomes, the scenarios were not intended to describe extreme or highly unlikely outcomes. Each scenario was intended to reflect reasonable representations of the values assumed for the individual variables combined in such a manner as to also represent reasonable plausible descriptions of UMR-IWW system unconstrained traffic. However, the likelihood of scenario occurrence, either numerical or ordinal, was not specified. The initial decision to not determine scenario probabilities was supported by the Federal Principals Task Force.

3. **Potential Options.**

a) One approach to accomplish scenario probability assignment would be Probabilistic Scenario Analysis (PSA). PSA is a representation of a sequence of events, choices, and their outcomes at different junctures in alternative sequences or chains of events that describe risky situations. It can be used to guide a risk assessment, to illuminate risk management and to support risk communication. PSA is an organized process with well-defined conventions useful in a wide variety of decision-making situations. (Standard protocols for eliciting information from experts exist. Two IWR documents "Methods for Expert-Opinion Elicitation of Probabilities and Consequences for Corps Facilities" http://www.iwr.usace.army.mil/iwr/pdf/MethodsforEEfinal1.PDF and "A Practical Guide on Conducting Expert-Opinion Elicitation of Probabilities and Consequences for Corps Facilities" http://www.iwr.usace.army.mil/iwr/pdf/PEEfinal.PDF provide guides for the process.) In a PSA there are two things that contribute to the overall uncertainty. One is knowledge uncertainty, which can be reduced with more time and money, more data, or more research. The second is inherent variability, which cannot be reduced unless you change the system being analyzed because it is inherent in the system. Because of inherent variability and knowledge uncertainty there are many possible scenarios. It is generally

not possible to describe them all but not all of them may be important to the decision process.

The structure of a PSA should follow a decision tree framework. The tree, however, must follow logic rules based on independence, dependence, and exclusivity of each branch. Additionally, in a PSA there must be a complete sequence so that a scenario follows a logic leading to a specific outcome. That is, no additional information must be required to complete a scenario.

To make the tree operational, probabilities of each tree branch and scenario outcomes must be provided. Expert elicitation is one method that can quantify probabilities where no data exists or when statistical methods are not possible. The basic approach is to develop a logic tree where each variable represents a branch point on the tree. Issues such as dependence, independence, and mutual exclusively among possible realizations of variables must be determined. This is necessary to assure the correct application of the rules of probability. In addition, the scenarios together must completely address all the possible realizations.

(Note: Although scenarios can be developed without probabilities, the resultant outcomes tend to be considered equally likely without additional information. This additional information is in the form of implied probabilities. In a true PSA, probabilities are used to calculate the resulting likelihood of the outcome from each scenario. When the analyst or decision-maker is asked to assess which realization he believes is the most likely, then probabilities are only implied. At each juncture in the scenario tree, only the most likely path is continued leading to a specific recommendation. Although this approach has previously been used by the Corps (Mt. St. Helen's) there is the potential danger of choosing a less likely outcome in complicated scenarios. In addition, since the degree of belief is not relevant, disagreement among multiple decision-makers may be difficult to resolve.)

There will likely be several difficulties applying PSA and expert elicitation. For instance, selecting an unbiased panel of experts who represent a balanced view of the multitude of variables that must be considered in predicting the development of world economic conditions over the next fifty years is highly problematic. Additionally, different sets of experts for different variables may be required. It should also be recognized that such expert panels frequently refuse to complete the elicitation task as originally structured. They may require a restructuring of scenarios or adding contributing variables not specified in an existing scenario. Issues of structure also exist. The scenarios as currently constructed do not necessarily conform to the decision tree framework of PSA, which requires a clear logical sequence of events. The appropriate sequencing of events in a scenario is not clear nor is whether there are any dependencies among the variables. Complete information as to all calculation details may also be problematic. In sum, the complexity of the issue of probabilities as described above, is far too great to expect any meaningful product from expert elicitation.

b) A second approach could be to employ expert elicitation, but not within a strict PSA framework. The objective would be to have the experts consider each scenario in its entirety and to produce a rank order listing of scenarios. The ordering would reflect relative likelihood of occurrence, but would not include assignment of numerical probabilities. Preferably, a consensus position would be developed. The advantage of this approach over PSA is that it would avoid the decision tree structure limitations of the scenarios as currently constructed. Shortcomings include one of the basic concerns associated with PSA, i.e., identifying neutral experts. Additionally, while affording some flexibility over PSA, the more free form nature of the process may result in a lesser degree of creditability. Reaching consensus may also be more difficult given that the experts would be required to consider scenarios in their entirety as compared to smaller individual components as would be the case with PSA.

4. **Federal Principals Task Force**. A Federal Principals Task Force meeting was held on 17 Dec. 02 at the Headquarters, U.S. Army Corps of Engineers (Corps) with participation from the U.S. Department of Agriculture, Agricultural Marketing Service (USDA, AMS), Environmental Protection Agency (EPA), and Maritime Administration (MARAD). The options for applying probabilities to scenarios were presented to the Principals Group and they confirmed their previous recommendation that probabilities not be assigned to the scenarios.

5. **Final Recommendation.** **T**he difficulties associated with PSA are likely to be too severe in the present case to overcome, and consequently this is not recommended. The alternative, less rigorous expert elicitation approach may add a veneer of " science," but is unlikely to produce meaningful or useful information for decision makers. Therefore it also is not recommended. Instead, the final recommendation is to continue with the process outlined in the Interim Report and not attempt to assign probabilities to scenarios. Currently the study is formulating and evaluating structural and non-structural navigation improvement and ecosystem restoration measures that will be the building blocks for any recommended plan for navigation efficiency and environmental sustainability. The formulation process and decision model to be used to select a recommended plan will be shared with the stakeholders as it is developed.

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